Game Changing Development

Low Cost Upper Stage (LCUS) Propulsion

Completed Technology Project (2014 - 2018)

Project Introduction

The LCUSP will demonstrate the ability to produce a low cost upper stage-class propulsion system using additive manufacturing technologies. LCUSP will do this by (1) developing a copper alloy additive manufacturing design process, (2) developing a new Nickel Jacket additive manufacture/application process, (3) additive manufacture a 25K-class regenerative chamber/nozzle, (4) testing components and then chamber/nozzle system in a hot fire resistance test.

Anticipated Benefits

NASA funded: Existing additive manufacturing (AM) equipment combined with new, enabling processes, and manufacturing 'best practices' will make it possible for more companies to build high quality rocket propulsion hardware at a lower cost and faster delivery than previously possible. These cost and schedule savings will be passed along to NASA when a new rocket engine is competed. AM can potentially offer an order of magnitude savings of cost and schedule for complex rocket propulsion hardware. AM process development for copper alloy, materials characterization, and technology transfer to industry will open new competitive markets that may reach beyond the space flight industry. Provide space industry with new material property database and proven techniques for implementing AM in their manufacturing process. NASA unfunded: Any future liquid propulsion system has the potential to benefit from this technology effort. OGA: Airforce propulsion programs and rocket engine development/procurement can benefit from lower cost and faster design cycles due to this technology. Commercial: Commercial Space Industry propulsion programs and rocket engine development can benefit from lower cost and faster design cycles due to this technology. Nation: New capabilities in fabrication of high strength difficult to work with parts compared to common materials will allow the USA to be more competitive in the world market. This fabrication process allows faster design cycles and iterations allowing for fabrication of parts that have not been possible using conventional methods. This technology will add a very capable tool for the Nations Space Program as well as many other applications.

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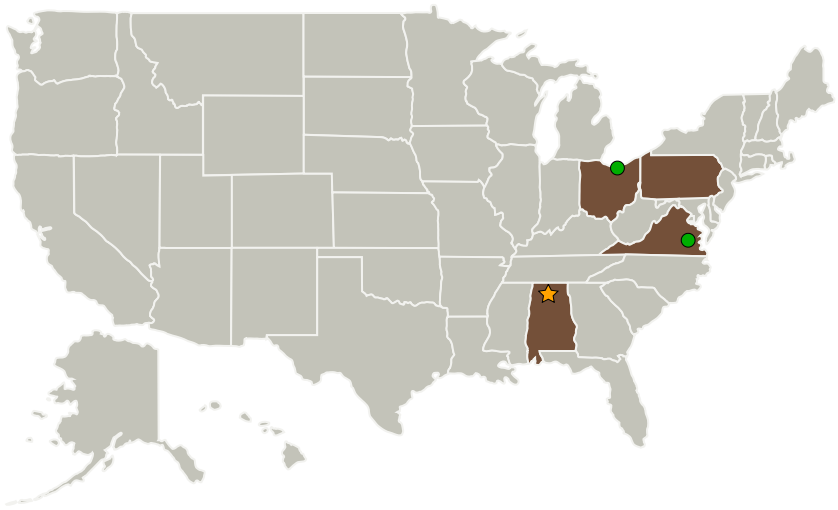
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Marshall Space Flight Center(MSFC)	Lead Organization	NASA Center	Huntsville, Alabama
●Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio
●Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
Alabama	Ohio
Pennsylvania	Virginia

Project Transitions

April 2014: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Marshall Space Flight Center (MSFC)

Responsible Program:

Game Changing Development

Project Management

Program Director:

Mary J Werkheiser

Program Manager:

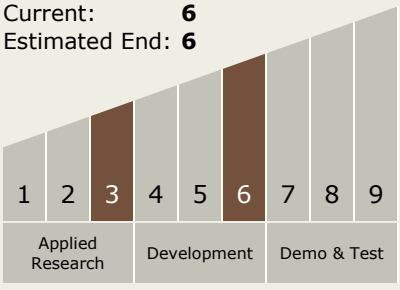
Gary F Meyering

Principal Investigator:

John C Fikes

Technology Maturity (TRL)

Start: **3**
Current: **6**
Estimated End: **6**



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June 2018: Closed out

Closeout Summary: The objective of this project was to demonstrate the use o f additive manufacturing to produce components for rocket engines, specifically thrust chambers. The project successfully demonstrated the first use of Selectiv e Laser Melting processing to produce a thrust chamber from GRCop-84 and the use of Electron Beam Free-Form Manufacturing to apply an Inconel 625 jacket o nto this thrust chamber to provide structural support. Two thrust chambers wer e hot fire tested at 100% power levels for 20 and 25 seconds and generated 29, 100 lb-f and 26,700 lb-f of thrust, respectively. This technology has been succes sfully transitioned to industry with all of the major aerospace primes now evalua ting the use of SLM processing of GRCop-84 engine components.

Stories

NASA 3-D Prints First Full-Scale Copper Rocket Engine Part
(https://techport.nasa.gov/file/164910)

Project Website:

https://www.nasa.gov/directorates/spacetech/game_changing_development/in

Target Destinations

The Moon, Earth